

INVESTOR IN PEOPLE

The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

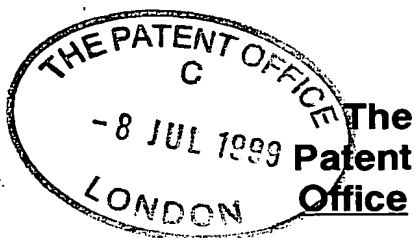
Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 20 March 2002

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Patents Form 1/77  
Patents Act 1977  
(Rule 16)



09JUL99 E460854-5 D02917  
P01/7700 0.00 - 9916084.8

## Request for grant of a patent

The Patent Office  
Cardiff Road  
Newport  
Gwent NP9 1RH

1.	Your reference	
	1830201/AM	
2.	Patent Application Number	
	9916084.8	
3.	Full name, address and postcode of the or of each applicant ( <i>underline all surnames</i> )	
	Scientific Generics Limited Harston Mill Harston Cambridgeshire CB2 5NH	
	Patents ADP number ( <i>if known</i> ) 56 93874003	
	If the applicant is a corporate body, give the country/state of its incorporation	Country: ENGLAND State:
4.	Title of the invention	
	FULL DUPLEX FREE SPACE OPTICAL COMMUNICATION SYSTEM	
5.	Name of agent	Beresford & Co
	"Address for Service" in the United Kingdom to which all correspondence should be sent	2/5 Warwick Court High Holborn London WC1R 5DJ
	Patents ADP number 1826001	
6.	Priority details	
	Country	Priority application number      Date of filing

# Patents Form 1/77

7. If this application is divided or otherwise derived from an earlier UK application give details

Number of earlier of application

Date of filing

8. Is a statement of inventorship and or right to grant of a patent required in support of this request?

NO

9. Enter the number of sheets for any of the following items you are filing with this form.

Continuation sheets of this form

Description

2

Claim(s)

Abstract

Drawing(s)

2

x2

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (*Patents form 7/77*)

1 + 2 COPIES

Request for preliminary examination and search (*Patents Form 9/77*)

Request for Substantive Examination (*Patents Form 10/77*)

Any other documents (*please specify*)

11. I/We request the grant of a patent on the basis of this application

Signature

*Beresford & Co*  
BERESFORD & Co

Date

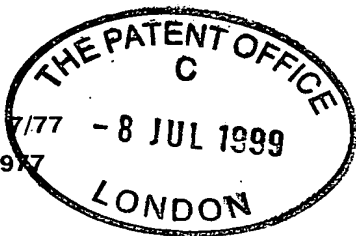
8 July 1999

12. Name and daytime telephone number of person to contact in the United Kingdom

ALAN MACDOUGALL

Tel:0171-831-2290

Patents Form 7/77  
Patents Act 1977  
(Rule 15)



**The  
Patent  
Office**

08 JUL 1999

**Statement of inventorship and of  
right to grant of a patent**

The Patent Office  
Cardiff Road  
Newport  
Gwent NP9 1RH

1. Your reference  
1830201/AM

**9916084.8**

2. Patent Application Number  
accompanying application reference 1830201

3. Full name of the or each applicant  
  
Scientific Generics Limited

4. Title of the invention  
  
FULL DUPLEX FREE SPACE OPTICAL COMMUNICATION SYSTEM

5. State how the applicant(s) derived the right from the inventor(s) to be granted a patent  
  
BY VIRTUE OF EMPLOYMENT.

6. How many, if any additional Patents Forms  
7/77 are attached to this form?  
  
NONE

11. I/We believe that the person(s) named over the page (and on any extra copies of this form) is/are  
the inventor(s) of the invention which the above patent application relates to.

Signature

*Beresford & Co*  
BERESFORD & Co

Date 8 July 1999

12. Name and daytime telephone number of  
person to contact in the United Kingdom

ALAN MACDOUGALL  
Tel: 0171-831-2290

**Patents Form 7/77**

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## **Full Duplex Free Space Optical Communication System**

### **Background**

The applicant has described in WO98/35328 an optical communication system employing a pixellated reflective modulator array combined with a telecentric optical system. The system operates by assigning each user of the system a unique pixel in the array. Each pixel in the array maps to a unique angular position in the field of view of the telecentric optical system (figure 1). The content of WO98/35328 is incorporated herein by way of reference.

Described in WO98/35328 is an implementation in which a low bandwidth control channel, between the receiver and modulator end may be achieved. This is achieved by employing a matched detector array, and by adding a small signal modulation to the laser source at the receiver. Such small signal modulation is known in fibre optic systems to implement a low bandwidth 'Supervisory' or 'Engineer's Order Wire' channel.

Our invention concerns an extension of this concept to full duplex operation with symmetrical bandwidth.

### **Description of the Invention**

Our invention exploits the fact that the optical loss in a free-space optical communication system according to WO98/35328 is asymmetrical.

In the following description, we refer to communication between the modulator and the receiver as the 'downlink' and between the receiver and the modulator as the 'uplink'. Generally, the uplink loss in such a system is considerable lower than the downlink loss. This is because the light originates in the receiver, and hence traverses the optical path once for the uplink, but twice for the downlink. Furthermore, there are additional losses in the system due to the sub-optimal reflectivity of the modulator etc.

The signal-to-noise ratio in an optical communication system is determined by a number of factors:

- Modulation depth
- Path loss
- Receiver noise

The achievable bit-error-rate (BER) in a Pulse Code Modulation (PCM) communication system is related to the signal-to-noise ratio via the error function,  $\text{erf}(x)$ .

Modulation depth normally affects the signal-to-noise ratio due to the fact that the CW component of the signal adds additional shot noise. In the case of a system according to WO98/35328, we can make use of the fact that there is 'excess' signal-to-noise ratio available in the uplink, since the path loss is lower. Therefore, we can reduce the modulation depth in the uplink, to a point where the uplink modulation is a small signal applied to a large CW signal (as described above for the provision of a low bandwidth control channel) as shown in figure 2.

The uplink modulation then simply becomes an additional noise source in the downlink (and hence causes some reduction on downlink signal-to-noise ratio, figure 3). However, if the uplink modulation depth is kept sufficiently low, both uplink and downlink can operate with equal data bandwidth.

Note that our invention exploits the asymmetrical optical path loss of systems according to WO98/35328. In cases where the path loss is symmetrical (e.g. most optical fibre systems), there is no favourable path loss direction and hence there is no opportunity to reduce the modulation depth in one direction. Systems with symmetrical path loss would, however, allow the total bandwidth of the system to exceed that of systems with asymmetrical path loss, and hence no fundamental bandwidth limitations are exceeded by our invention.



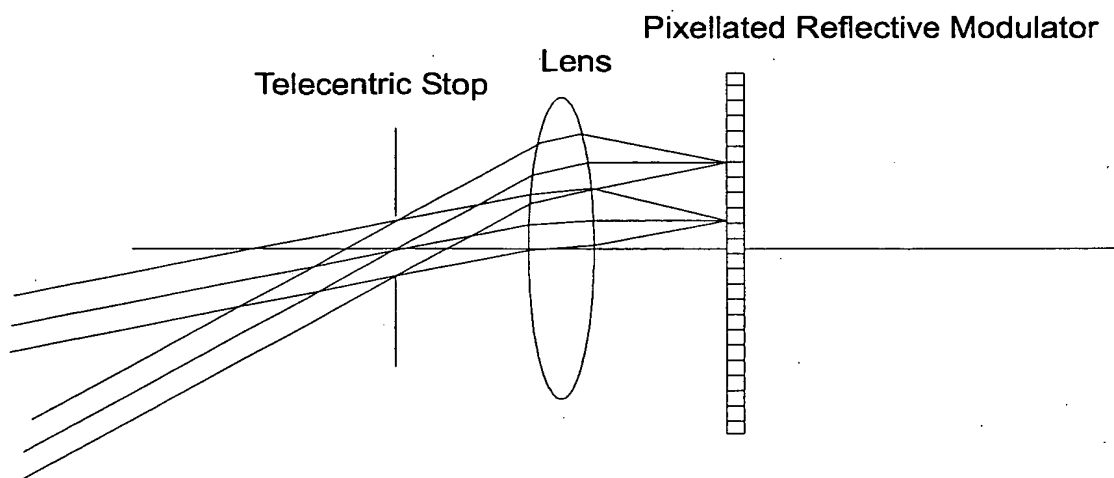


Figure 1

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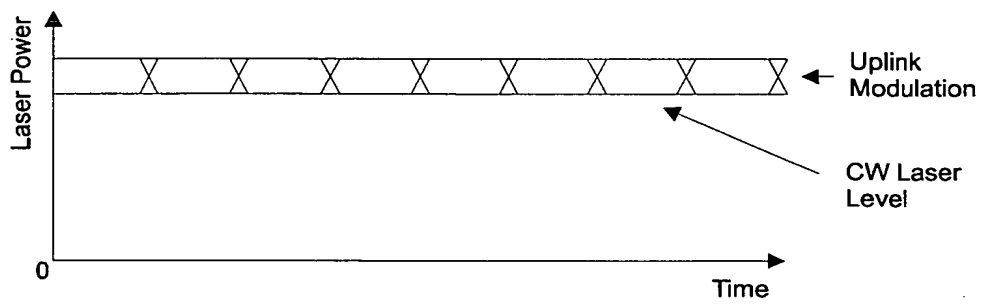


Figure 2

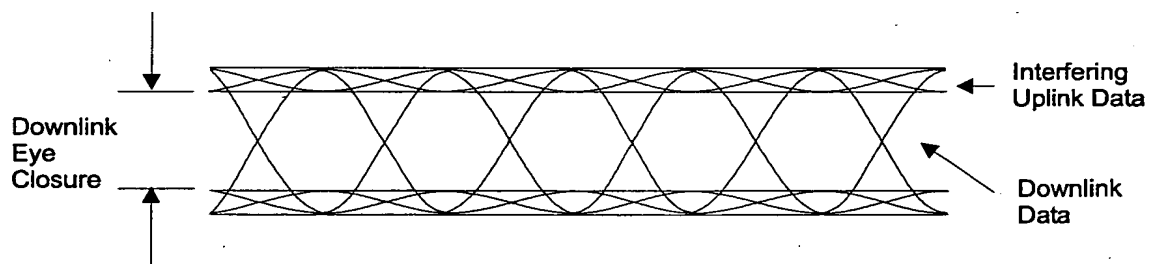


Figure 3

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